UNIZG-FER 222464

Arhitektura, protokoli i usluge weba (*Web Architecture, Protocols, and Services*)

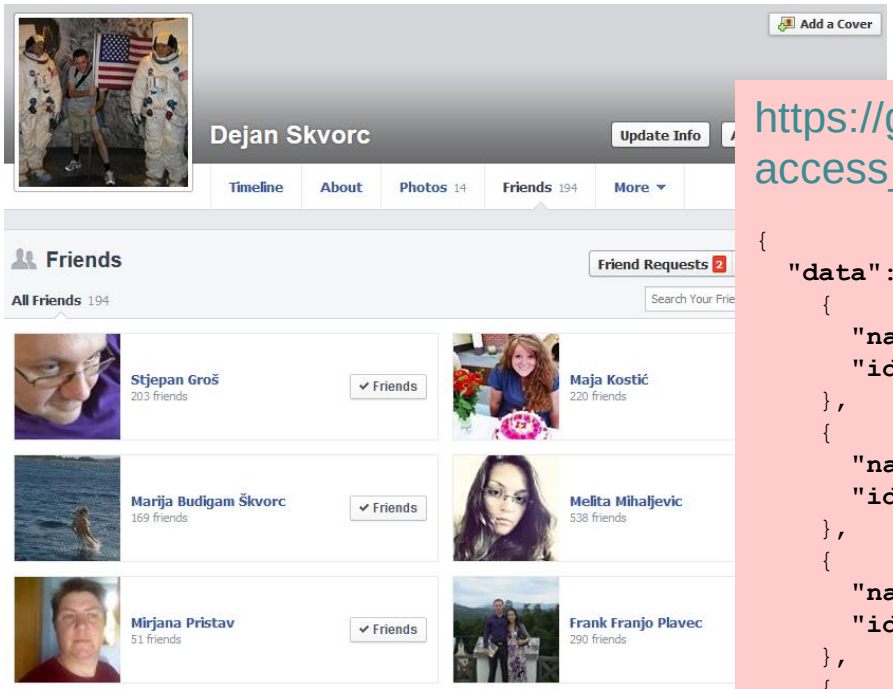
http://www.fer.unizg.hr/predmet/apuw

Izv. prof. dr. sc. Dejan Škvorc
Izv. prof. dr. sc. Klemo Vladimir
Izv. prof. dr. sc. Goran Delač
Prof. dr. sc. Siniša Srbljić

Sveučilište u Zagrebu
Fakultet elektrotehnike i računarstva
Zavod za elektroniku, mikroelektroniku, računalne i inteligentne sustave

Web Services

https://www.facebook.com/dejan.skvorc/friends



https://graph.facebook.com/v3.1/625589/friends?access_token=CRaFYZB0Tt

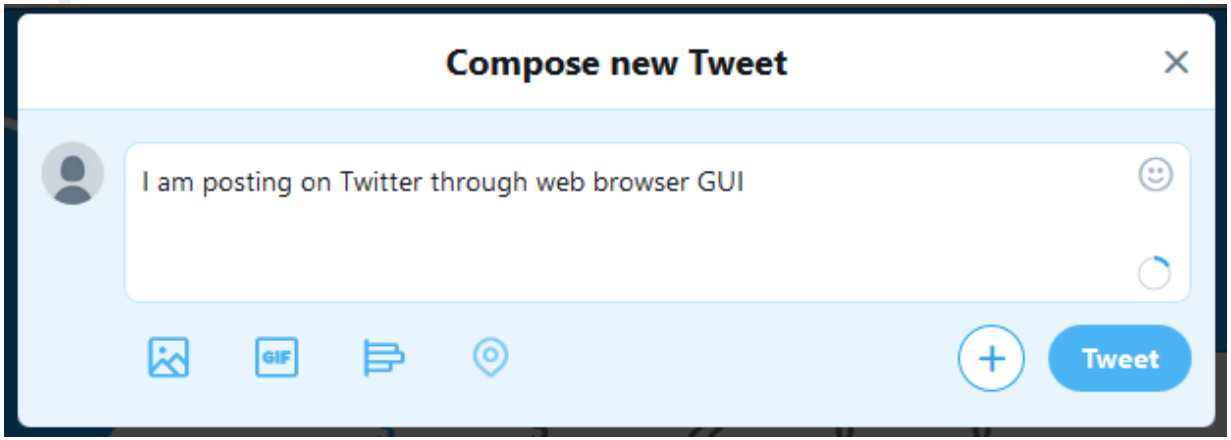

```
{
  "data": [
    {
      "name": "Stjepan Gros",
      "id": "https://graph.facebook.com/670874"
    },
    {
      "name": "Maja Kostic",
      "id": "https://graph.facebook.com/281205"
    },
    {
      "name": "Marija Budigam Skvorc",
      "id": "https://graph.facebook.com/281288"
    },
    {
      "name": "Melita Mihaljevic",
      "id": "https://graph.facebook.com/526274"
    },
    {
      "name": "Mirjana Pristav",
      "id": "https://graph.facebook.com/828064"
    },
    {
      "name": "Frank Franjo Plavec",
      "id": "https://graph.facebook.com/428934"
    }
  ]
}
```

Web Services

https://twitter.com/dejanskvorc

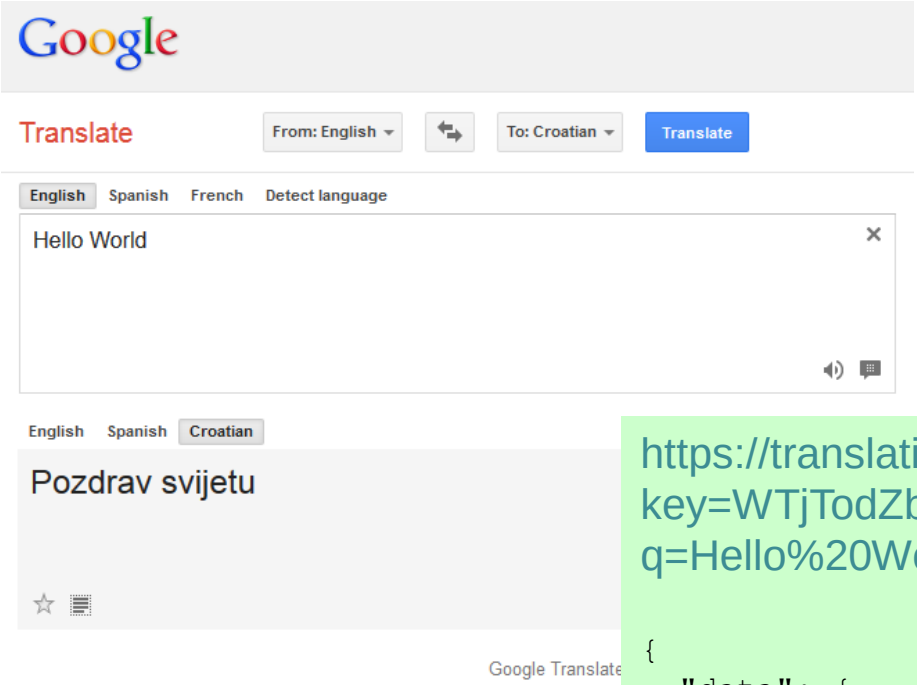
https://api.twitter.com/1.1/statuses/update.json

```
status=I+am+posting+on+Twitter+programmatically&
lat=45.801319&
long=15.970826
```



Web Services

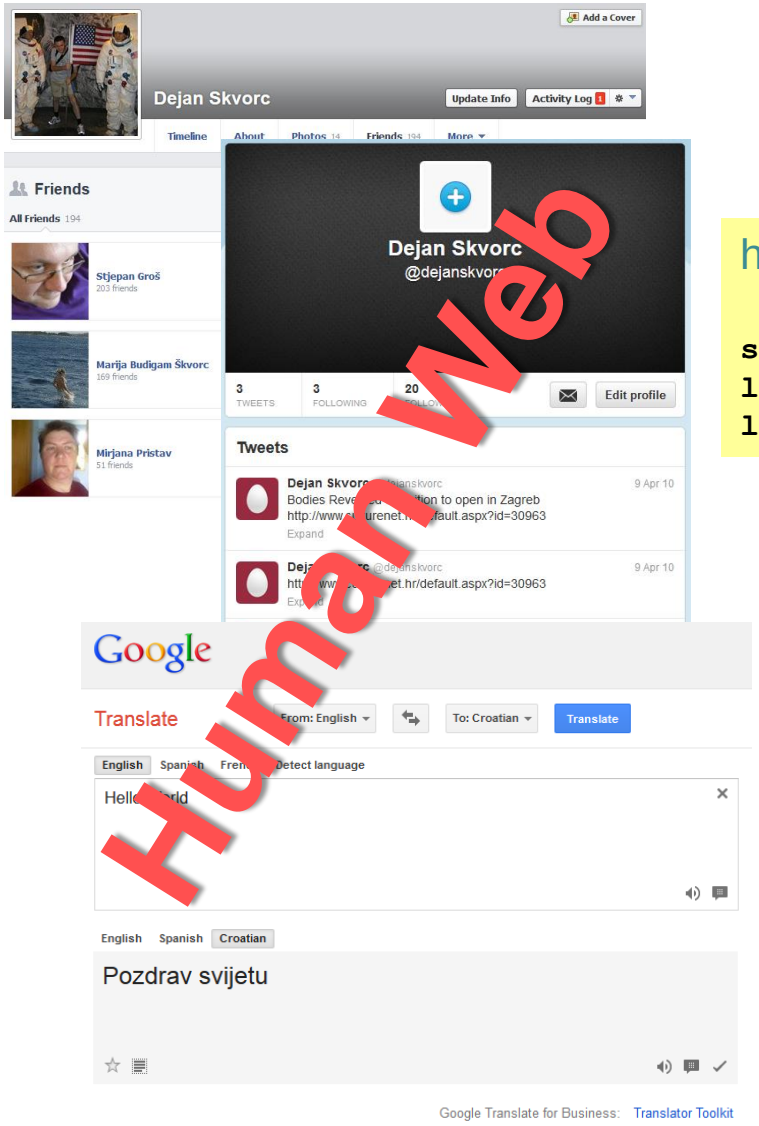
http://translate.google.com



https://translation.googleapis.com/language/translate/v2?key=WTjTodZba7ky7&source=en&target=hr&q=Hello%20World


```
{
  "data": {
    "translations": [
      {
        "translatedText": "Pozdrav svijetu"
      }
    ]
  }
}
```

Web Services



Human Web

https://graph.facebook.com/625589/friends


```
{
  "data": [
    {
      "name": "Stjepan Gros",
      "id": "https://graph.facebook.com/670874"
    },
    {
      "name": "Melita Milaljevic
```


https://api.twitter.com/1.1/statuses/update.json

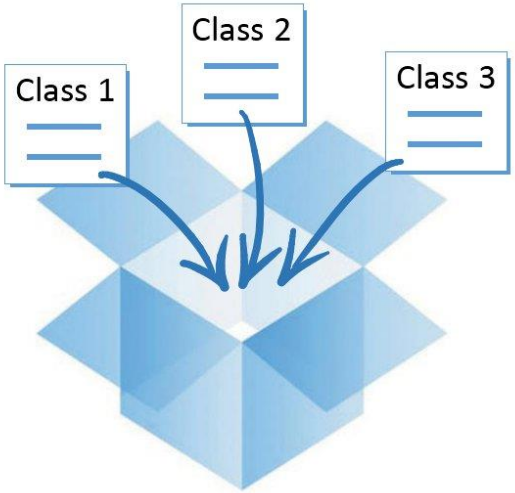

```
status=I+am+programmatically+posting+on+Twitter&
lat=45.801319&
long=15.970826
```


https://www.googleapis.com/language/translate/v2?key=WTjTodZba7kjZ&source=en&target=hr&q=Hello%20World


```
{
  "data": {
    "translations": [
      {
        "translatedText": "Pozdrav svijetu"
      }
    ]
  }
}
```


Programmable Web

Web Services



Service-oriented computing

apply preinstalled components
buy components
get open source components
develop components by yourself

local installation and execution

software as a product

rent software *functionalities*

no installation
no ownership
remote execution
invocation on demand

software as a service (SaaS)

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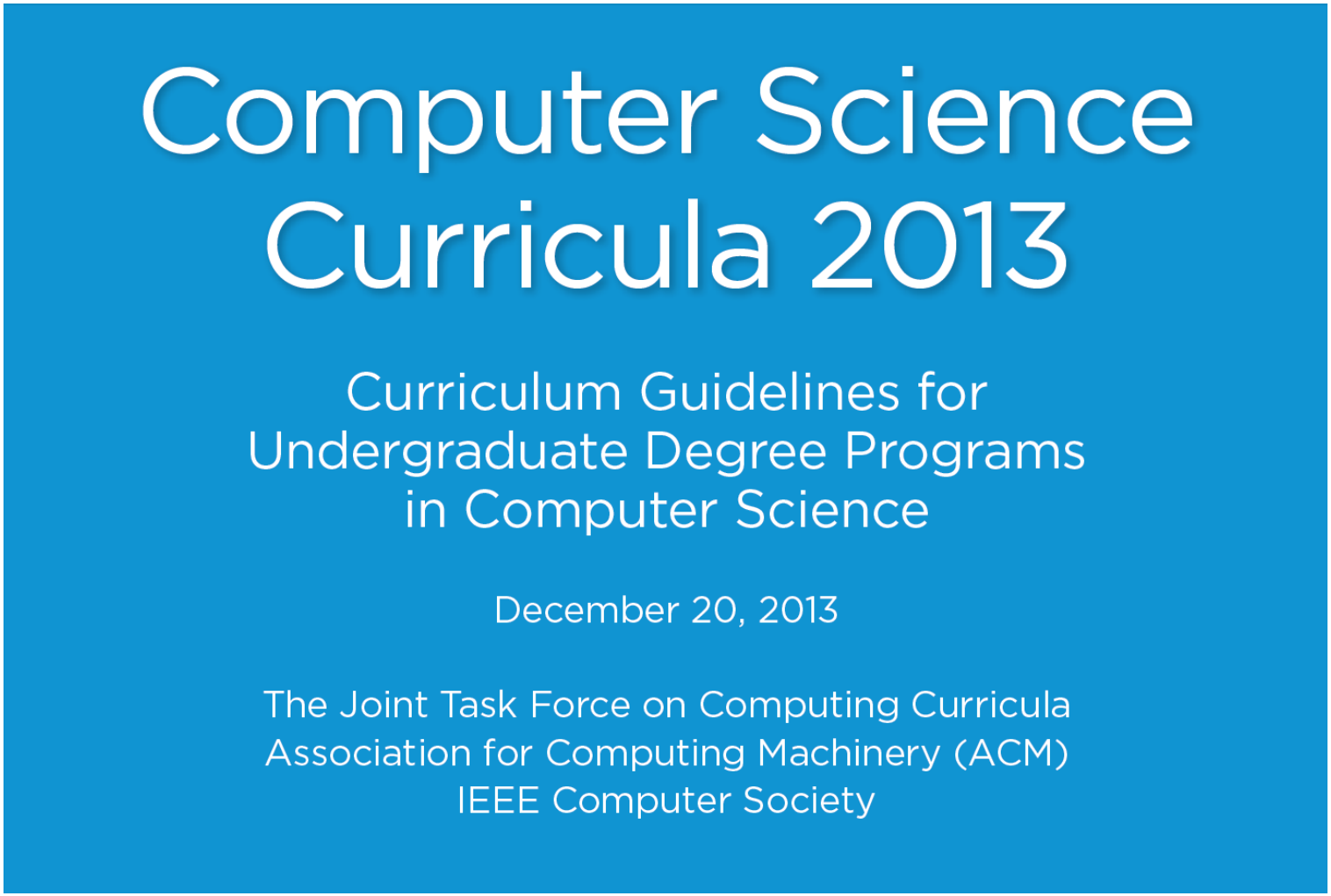
Course Motivation



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Course Motivation

- The CS2013 Body of Knowledge is organized into a set of 18 Knowledge Areas (KAs)
  - AL - Algorithms and Complexity
  - AR - Architecture and Organization
  - CN - Computational Science
  - DS - Discrete Structures
  - GV - Graphics and Visual Computing
  - HCI - Human-Computer Interaction
  - IAS - Information Assurance and Security
  - IM - Information Management
  - IS - Intelligent Systems
  - **NC - Networking and Communications**
  - OS - Operating Systems
  - **PBD - Platform-based Development**
  - PD - Parallel and Distributed Computing
  - PL - Programming Languages
  - SDF - Software Development Fundamentals
  - SE - Software Engineering
  - SF - Systems Fundamentals
  - SP - Social Issues and Professional Practice

Course Motivation

- NC - Networking and Communication
  - **CC2001 introduced a KA entitled "Net-Centric Computing" which encompassed a combination of topics including traditional networking, web development, and network security.** Given the growth and divergence in these topics since the last report, we renamed and re-factored this KA to focus specifically on topics in networking and communication. **Discussions of web applications and mobile device development are now covered in the new PBD-Platform-Based Development KA**. Security is covered in the new IAS-Information Assurance and Security KA.

- PBD - Platform-Based Development
  - PBD is a new KA that recognizes the increasing use of platform-specific programming environments, both at the introductory level and in upper-level electives. **Platforms such as the Web or mobile devices** enable students to learn within and about environments constrained by hardware, APIs, and special services (often in cross-disciplinary contexts). **These environments are sufficiently different from "general purpose" programming** to warrant this new (wholly elective) KA.

Course Motivation

- PBD / Web Platforms

Topics:

- Web programming languages (HTML5, Java Script, PHP, CSS, etc.)
- **Web platform constraints**
- **Software as a Service (SaaS)**
- Web standards

Learning Outcomes:

- Design and implement a simple web application
- **Describe the constraints that the web puts on developers**
- Compare and contrast web programming with general purpose programming
- **Describe the differences between Software-as-a-Service and traditional software products**
- Discuss how web standards impact software development
- Review an existing web application against a current web standard

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What This Course IS About?

- Web as a global information system
  - How it works?
    - Client (not only web browser)
    - Server
    - Search engine
- Web architecture
  - Principles
  - Properties
  - REST
- Protocols and interaction technologies
  - Hypermedia
  - URIs
  - HTTP, WebSocket
- RESTful API design
  - Resources
  - Naming and addressing
  - Representation and manipulation
  - Best practices

```
ALL   = Type.new "*/*", :all
TEXT  = Type.new "text/plain", :text
HTML  = Type.new "text/html", :html, %w
JS    = Type.new "text/javascript", :js
ICS   = Type.new "text/calendar", :ics
CSV   = Type.new "text/csv", :csv
XML   = Type.new "application/xml", :xm
```

What This Course IS NOT About?

- Web application development
  - Client side technologies
    - HTML
    - CSS
    - JavaScript
    - XML
  - Server side technologies
    - Java, JSP
    - PHP
    - Python, Node.js
    - CGI
    - ASP, ASP.NET
  - Database design
  - Application design paradigms
    - Three-tiered architecture
    - Model-View-Controller
  - Development frameworks
    - Angular, Ruby on Rails, Laravel
    - Django
    - Joomla

Course Organization

Lecturers

Izv. prof. dr. sc. Dejan Škvorc
Izv. prof. dr. sc. Klemo Vladimir
Izv. prof. dr. sc. Goran Delač

Assistants

Dr. sc. Lucija Šikić
Helena Čeović, mag. ing.
Ivan Mikulić, mag. ing.
Marin Vlaić, mag. ing.

ECTS: 5

Lecture type	Total load
Lectures	30
Laboratory exercises	5

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Lectures

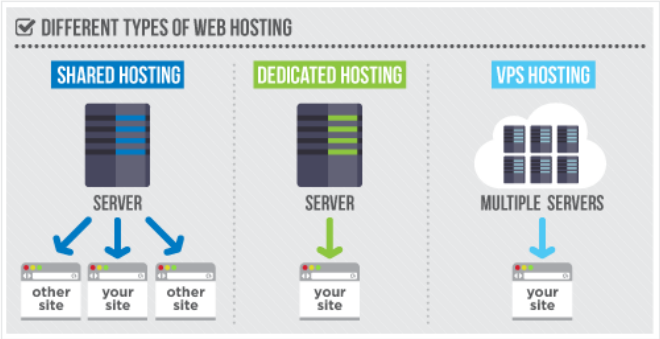
PART 1

- RESTful web services
  - REST architectural style
    - REST triangle
  - Resource-oriented architecture
    - Addressability
    - Statelessness
    - Uniform interface
    - Connectedness
  - HTTP
    - Resources
    - URIs
    - Methods
    - Media types
    - Representations
    - Response codes
    - Caching
    - Security
    - Content negotiation
  - REST maturity model

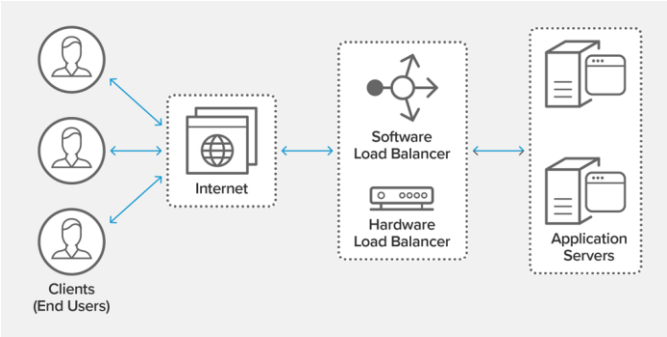
Lectures

PART 2

- Web hosting

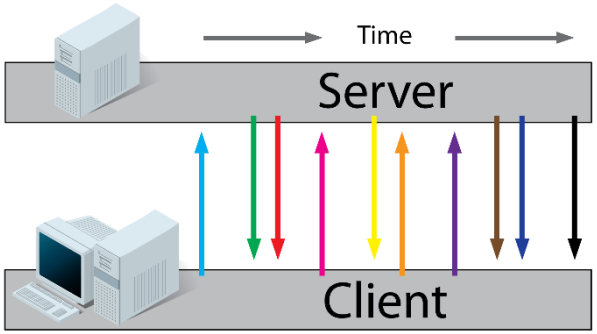


- Web server load balancing



- Server push paradigms and technologies
  - Polling, long polling
  - Server-sent events (SSE), AJAX

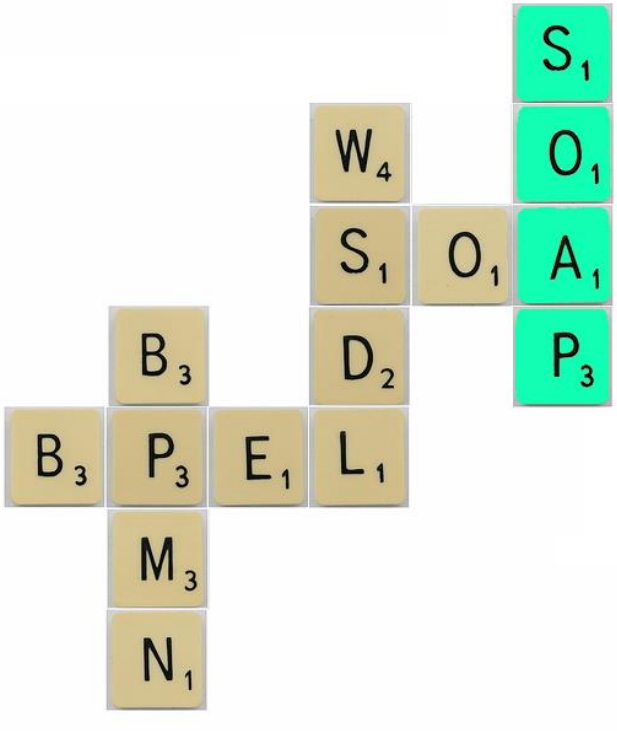
- Emerging web protocols
  - WebSocket



Lectures

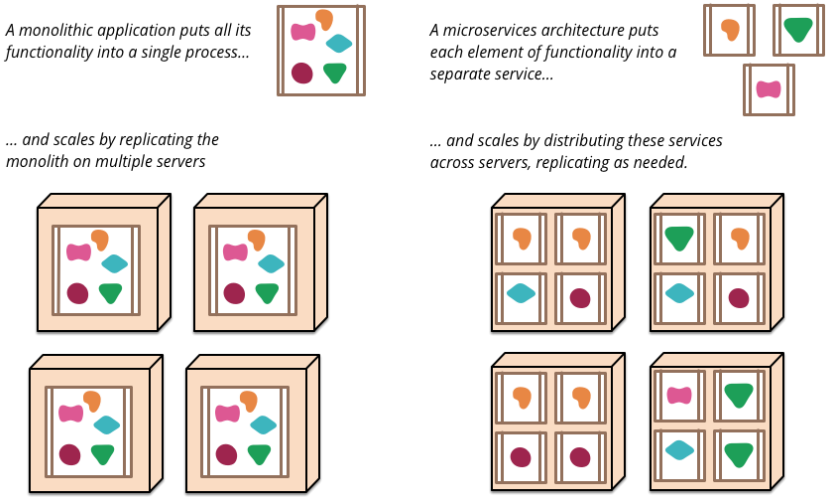
PART 3

- SOAP-based web services
  - Service-oriented architecture
    - SOA triangle
  - WS-* technology stack
    - SOAP
    - WSDL
    - UDDI
    - WS-Security
  - Quality of service
  - Service composition
  - Service-oriented programming model



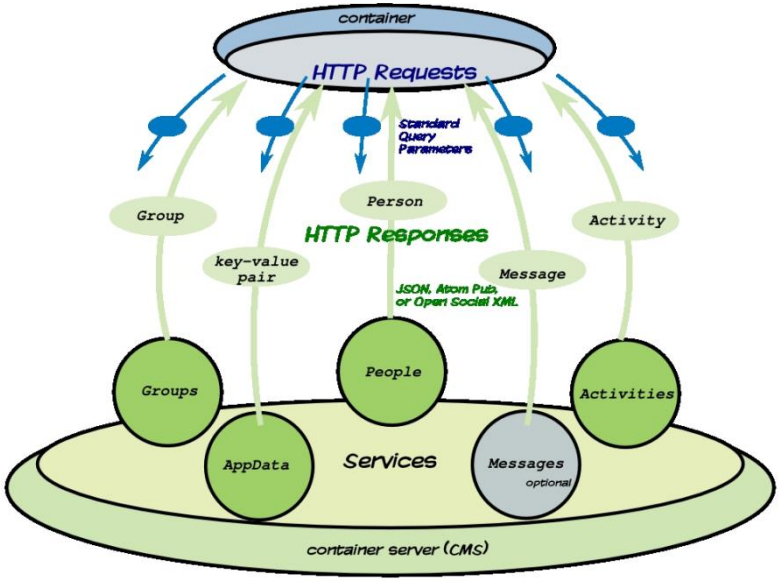
- RPC frameworks

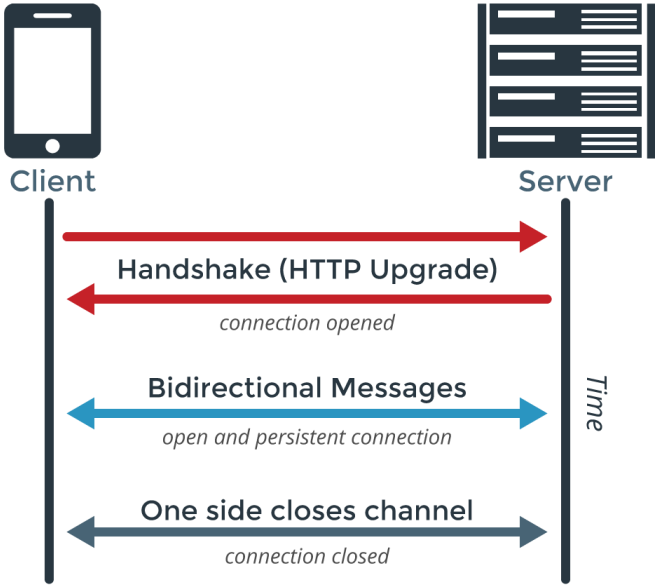
- Microservices architecture



Laboratory Exercises

- Individual work
- Two assignments
  - REST
  - Websocket
- Oral examination
  - Program demonstration
  - Oral examination





Reading Material

- **RESTful Web Services**

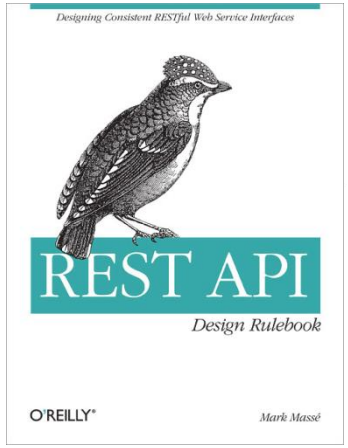
  Leonard Richardson, Sam Ruby

  O'Reilly Media, May 2007 (total pages: 454)

- **REST API Design Rulebook**

  Mark Masse

  O'Reilly Media, October 2011 (total pages: 116)

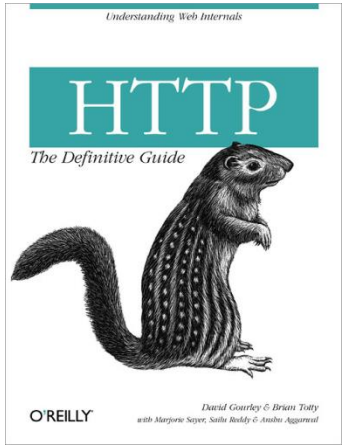


- **HTTP The Definitive Guide**

  David Gourley, Brian Totty, Marjorie Sayer,

  Anshu Aggarwal, Sailu Reddy

  O'Reilly Media, September 2002 (total pages: 658)



- Scientific articles, technical papers, excerpts from master theses and doctoral dissertations
- Web search (podcasts, blogs, discussion sites)

Provjera znanja i ocjenjivanje

1) Kontinuirana provjera znanja

Teorijski dio ocjene

- Međuispit 30 bodova
- Završni ispit 30 bodova
- **Ukupno 60 bodova**

Praktični dio ocjene

- Laboratorijske vježbe 40 bodova
- **Ukupno 40 bodova**

UKUPNO TEORIJA + PRAKSA

- 100 bodova

Provjera znanja i ocjenjivanje

1) Kontinuirana provjera znanja

Bodovni pragovi

- za dobivanje pozitivne ocjene
  - prag iz teorijskog dijela ocjene 30 / 60 bodova (50 %)
  - prag iz praktičnog dijela ocjene 20 / 40 bodova (50 %)

Određivanje ocjene

- dovoljan (2) 50 bodova
- dobar (3) 63 bodova
- vrlo dobar (4) 75 bodova
- izvrstan (5) 88 bodova

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Provjera znanja i ocjenjivanje

2) Ispitni rok

Pismeni i/ili usmeni ispit

- 100 bodova

Bodovni pragovi za izlazak na ispitni rok

- prag iz praktičnog dijela ocjene 20 / 40 bodova (50 %)
- NE ULAZI U OCJENU PISMENOG ISPITA

Određivanje ocjene

- dovoljan (2) 50 bodova
- dobar (3) 63 bodova
- vrlo dobar (4) 75 bodova
- izvrstan (5) 88 bodova

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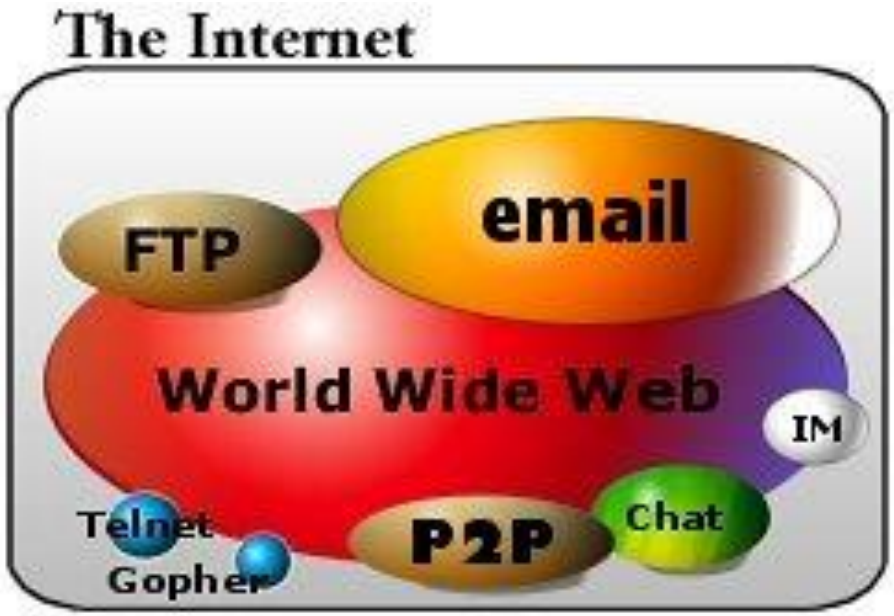
Web Architecture, Protocols, and Services

Short Introduction to the World Wide Web

Internet vs. World Wide Web

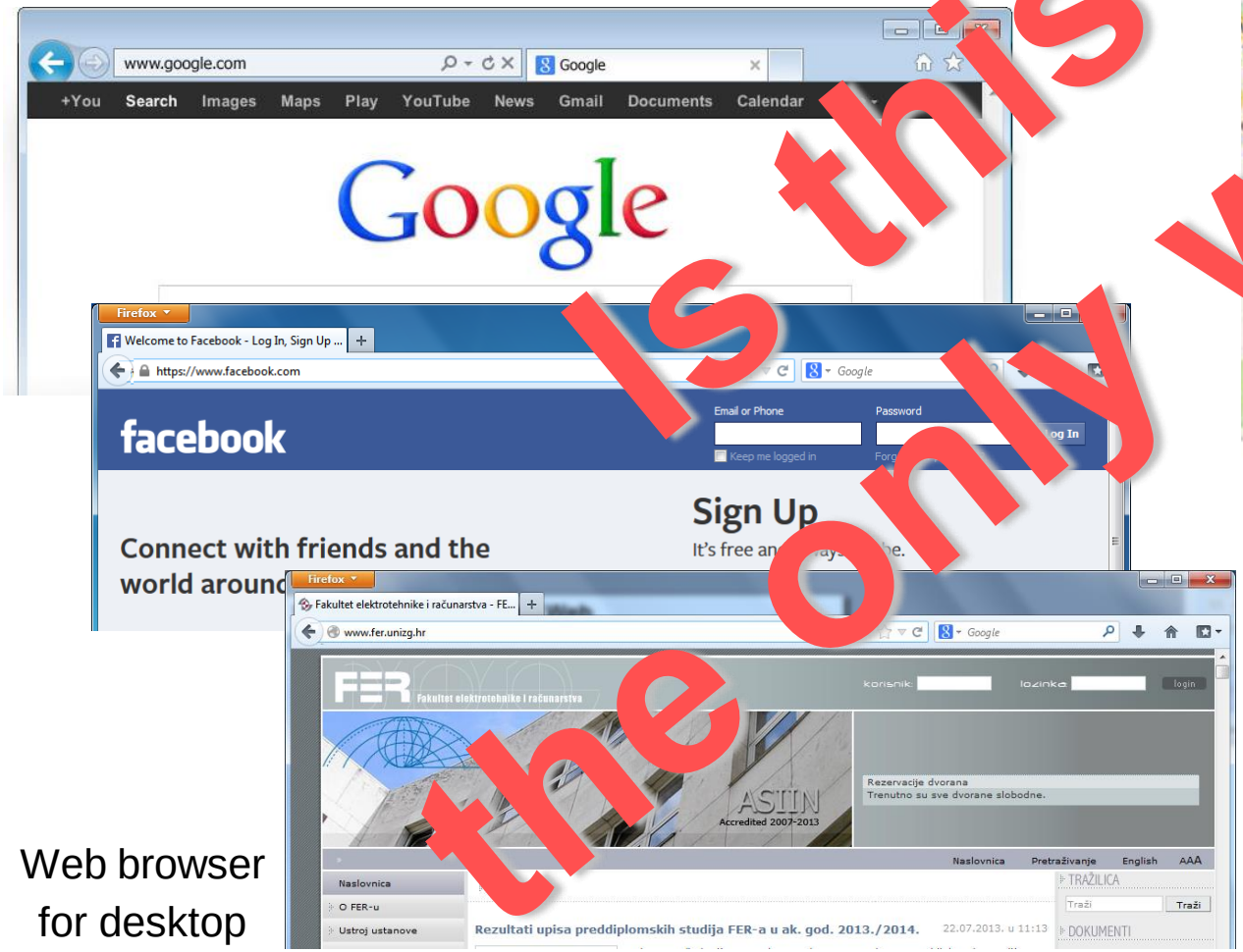
- Internet ≠ World Wide Web



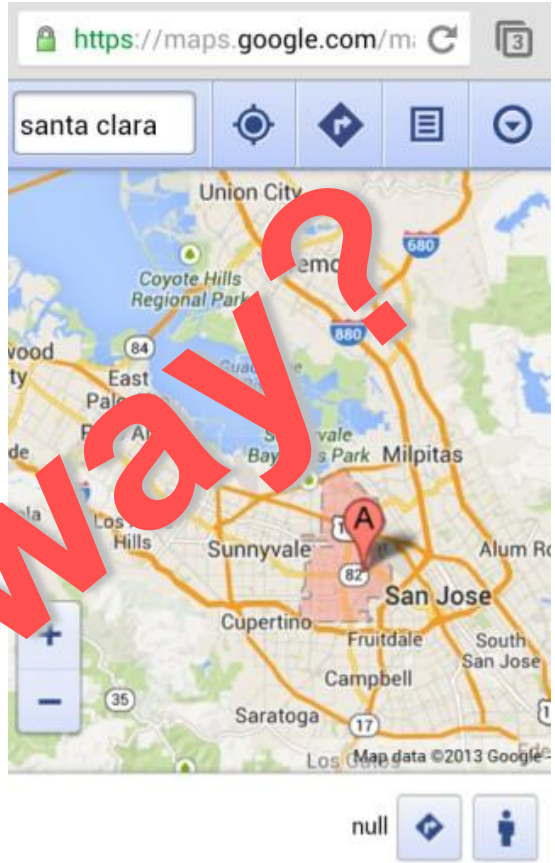
- Internet
  - Global network of networks, all using the same protocol: TCP/IP
- World Wide Web = Web = WWW
  - Just one application among many that uses the Internet

Internet vs. World Wide Web

- Access to the World Wide Web
  - Typically using a Web browser



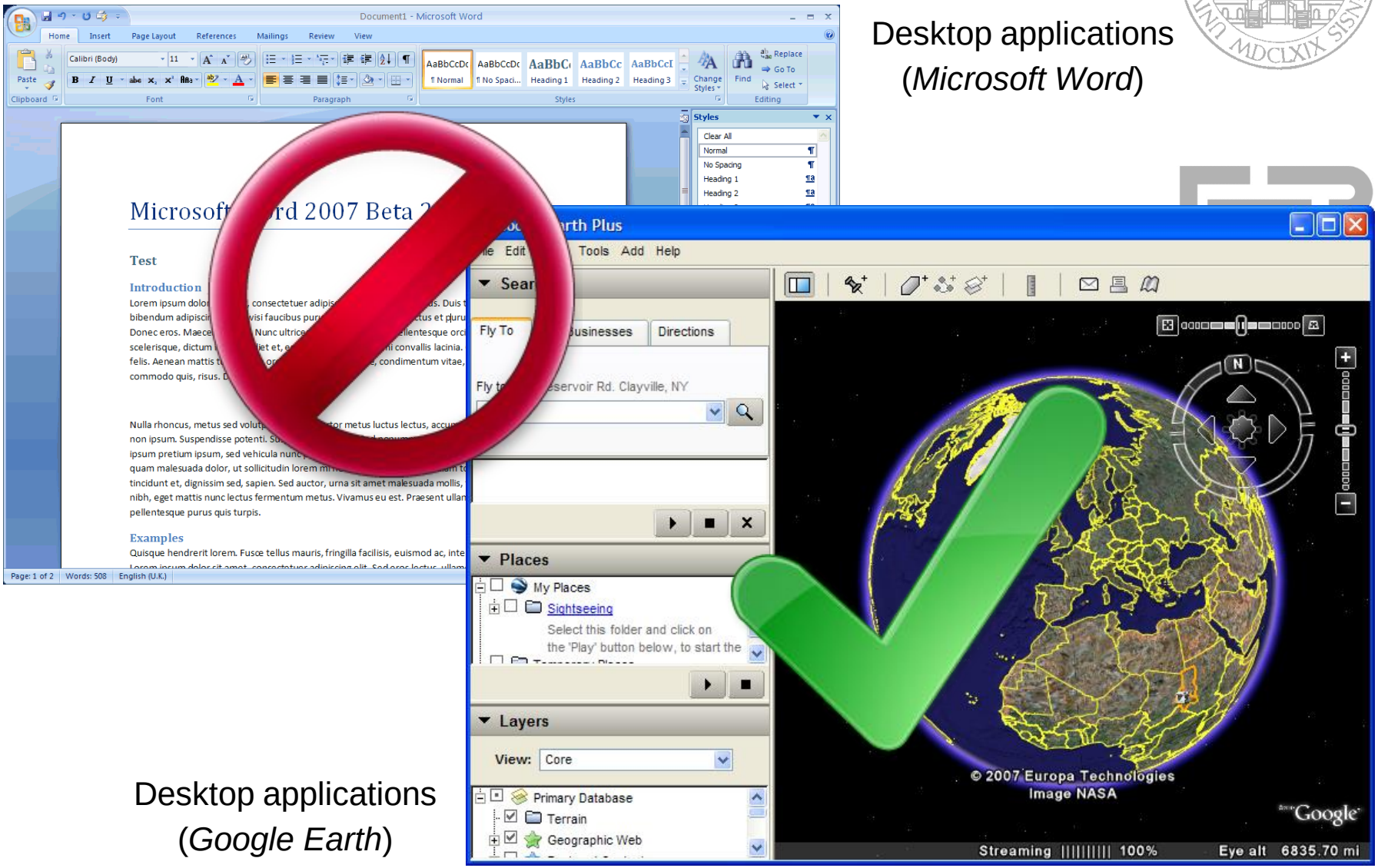
Web browser for desktop



Web browser for mobile

Is this the only way?

Internet vs. World Wide Web



Desktop applications (*Microsoft Word*)

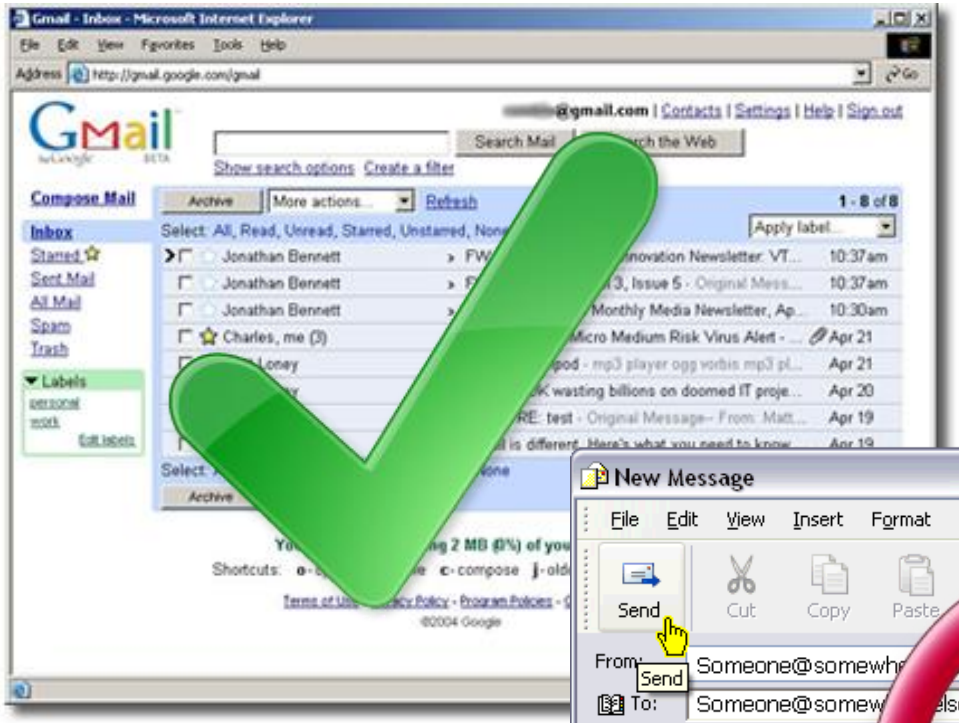
Desktop applications (*Google Earth*)

Internet vs. World Wide Web

Native mobile applications
(*Google Maps, Facebook*)

Native mobile applications
(*Phone, Camera*)

Internet vs. World Wide Web

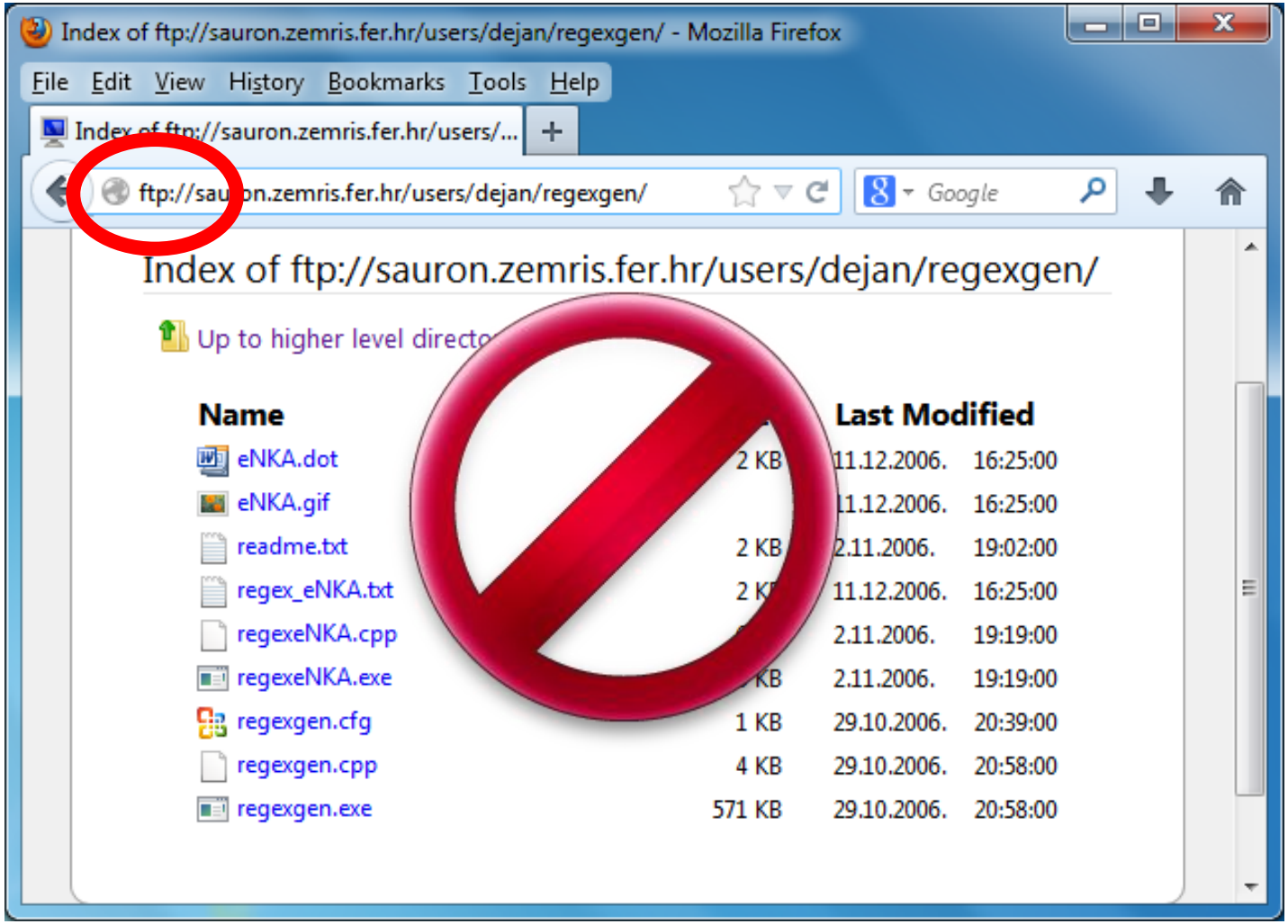


Webmail
(*GMail,*
Hotmail,
Yahoo! Mail)

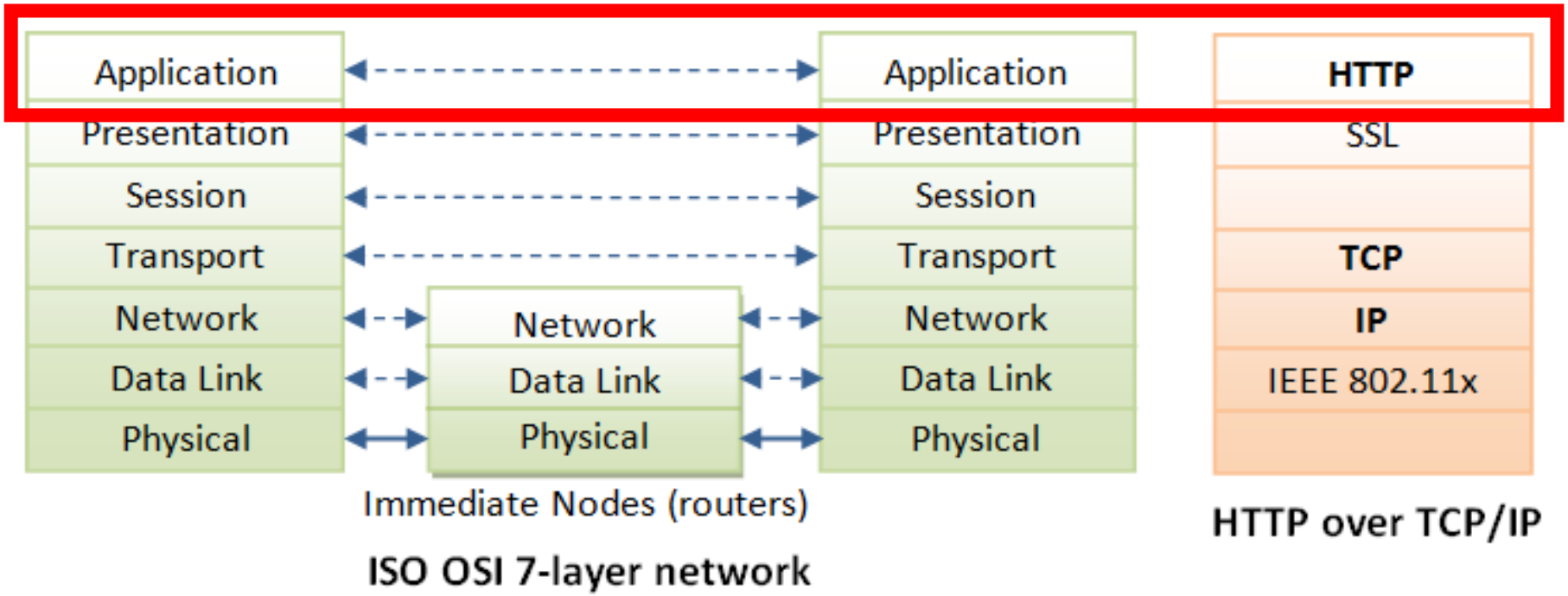
Desktop email client
(*MS Outlook,*
Mozilla Thunderbird)

Internet vs. World Wide Web

- Are we always on the Web when using a web browser?



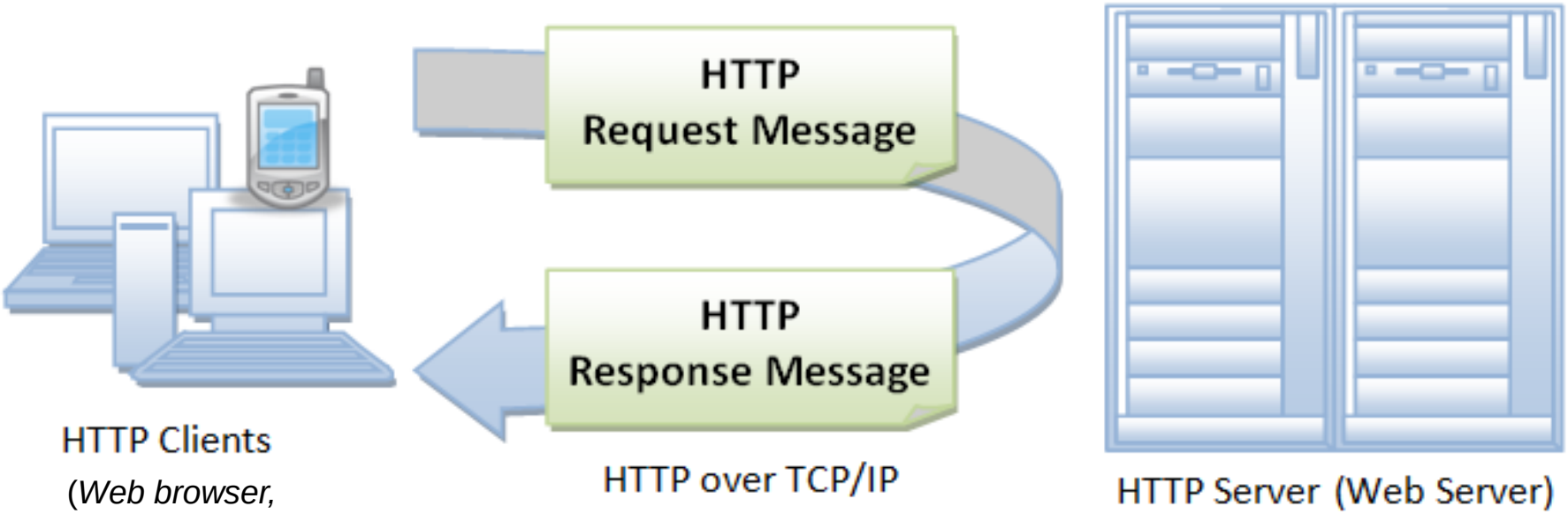
Internet vs. World Wide Web



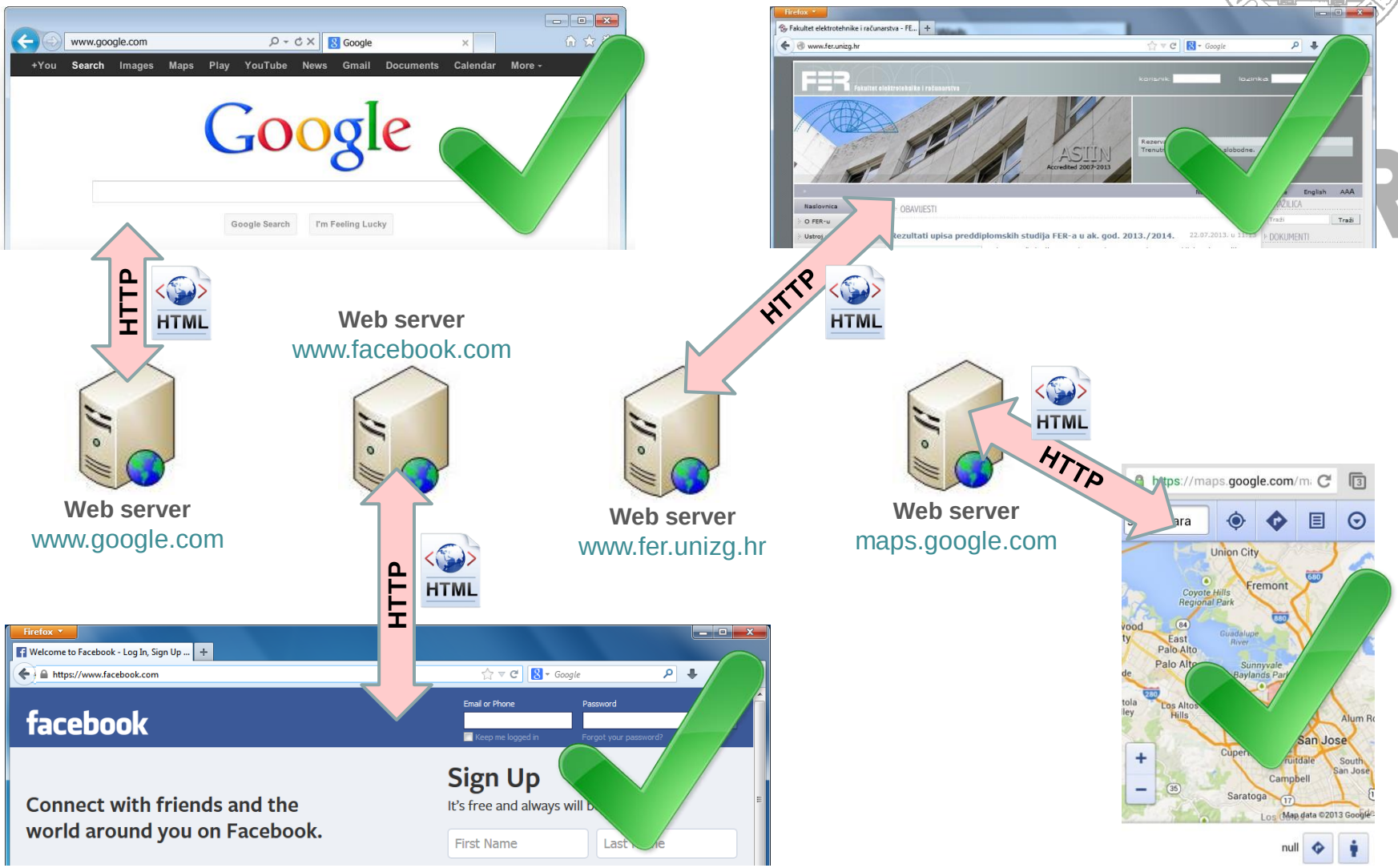
- **World Wide Web**
  - Applications and services based on **HTTP protocol**

Internet vs. World Wide Web

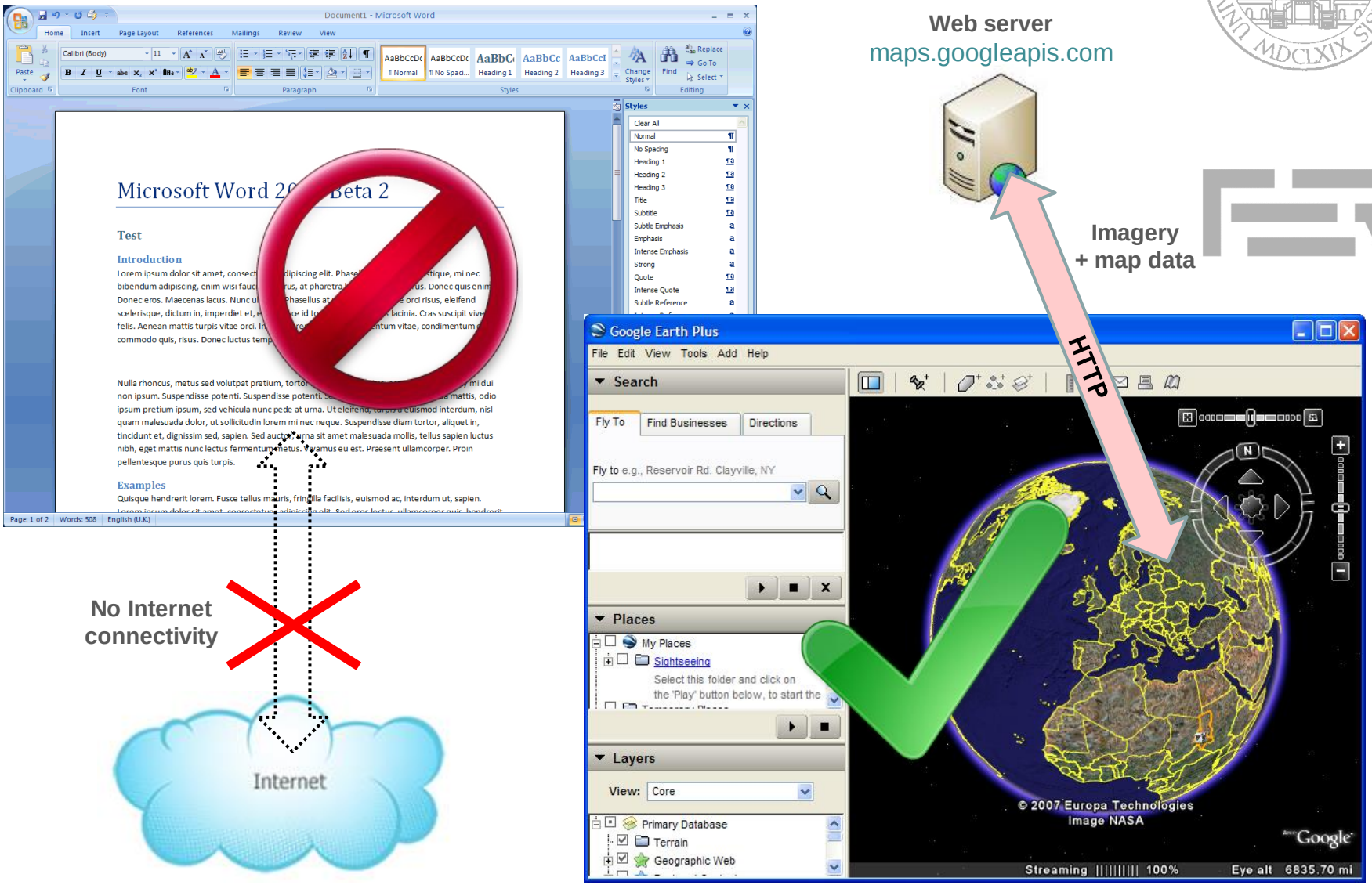
- HTTP (*HyperText Transfer Protocol*) protocol
  - Client-server architecture
  - Request-response paradigm



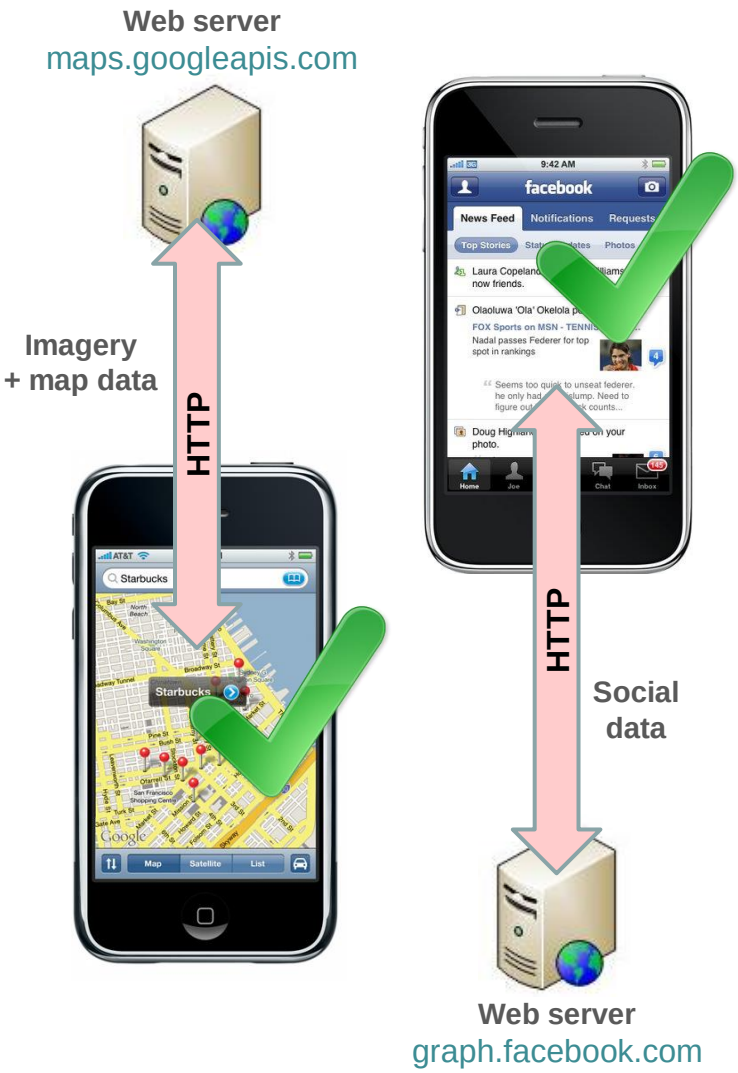
Internet vs. World Wide Web

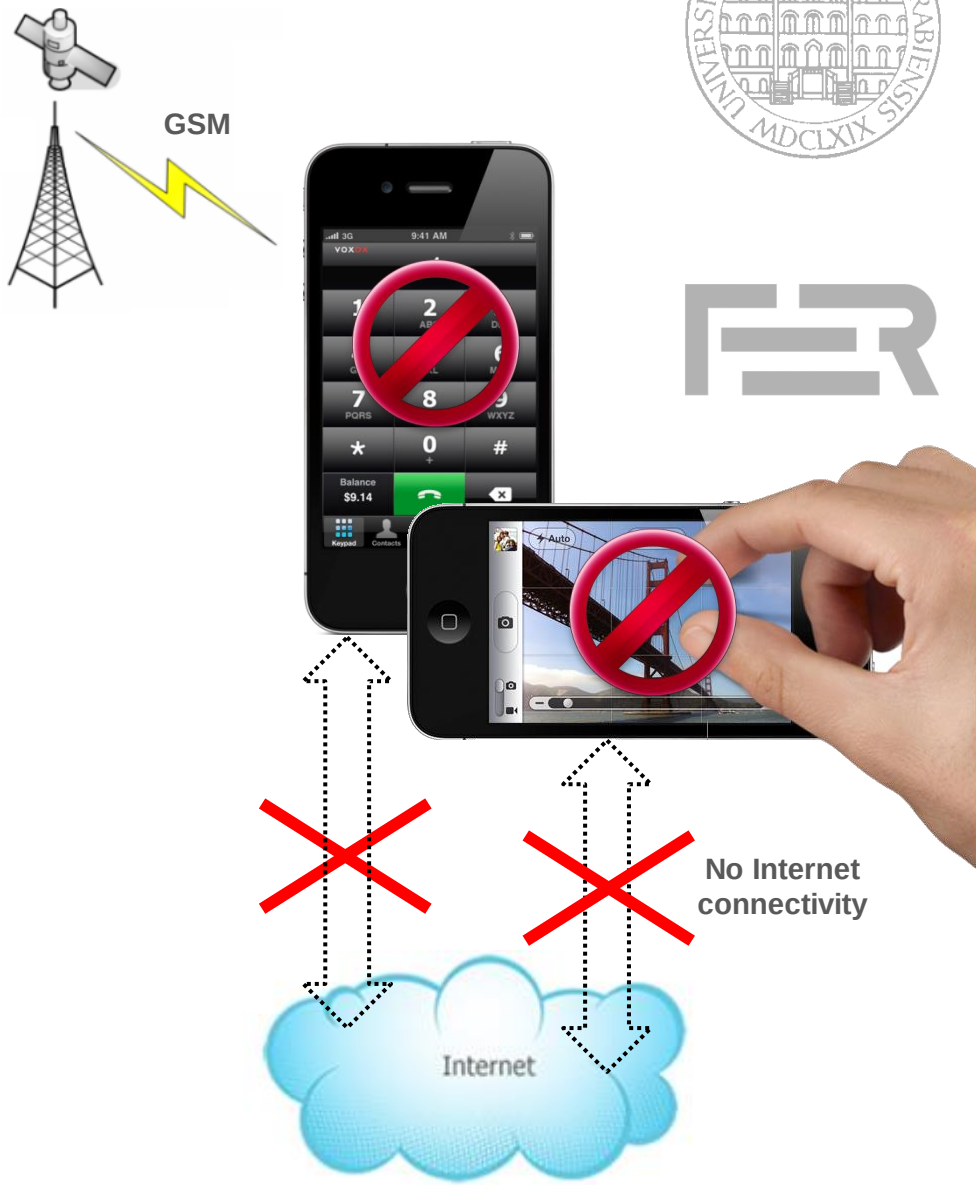


Internet vs. World Wide Web

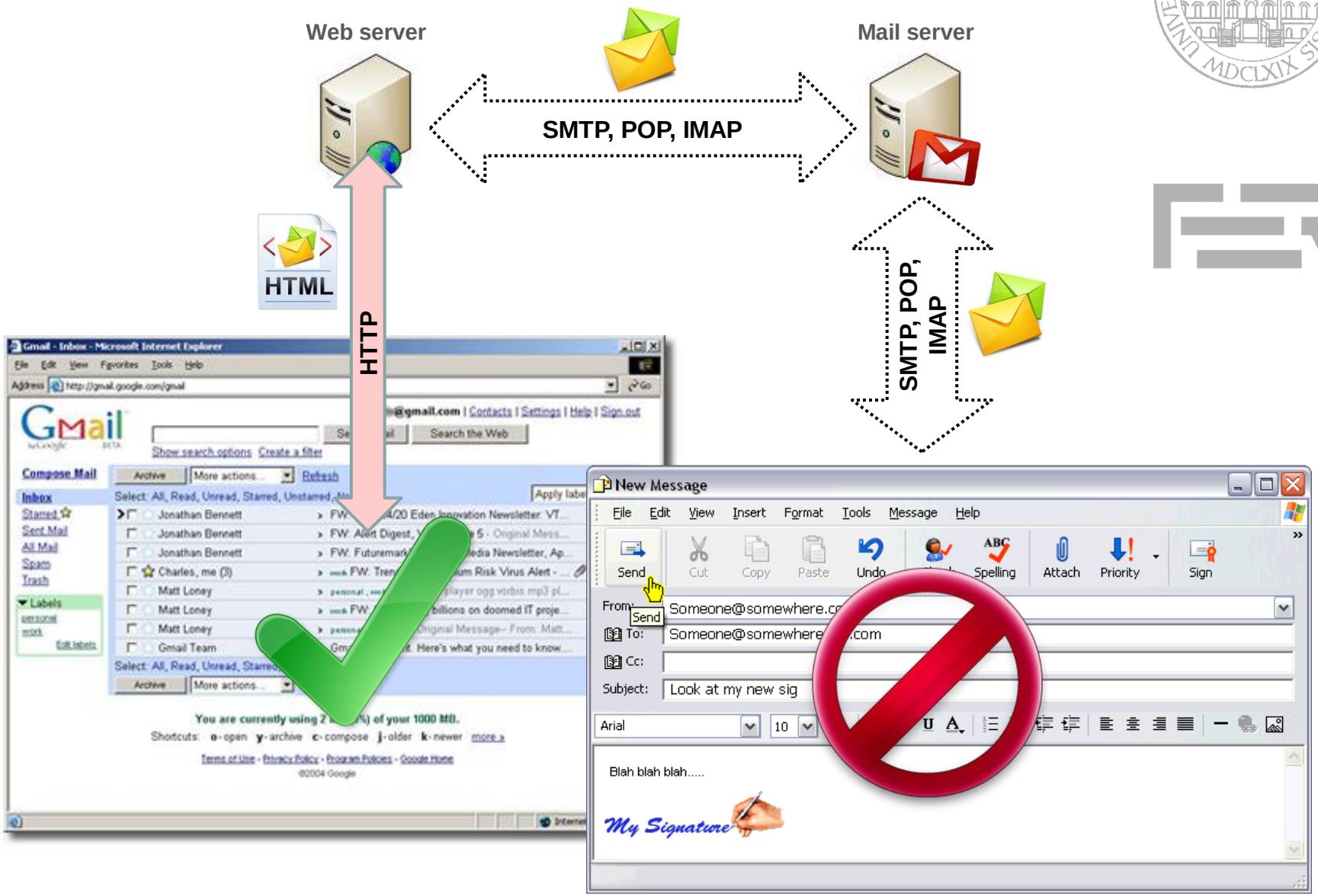


Internet vs. World Wide Web

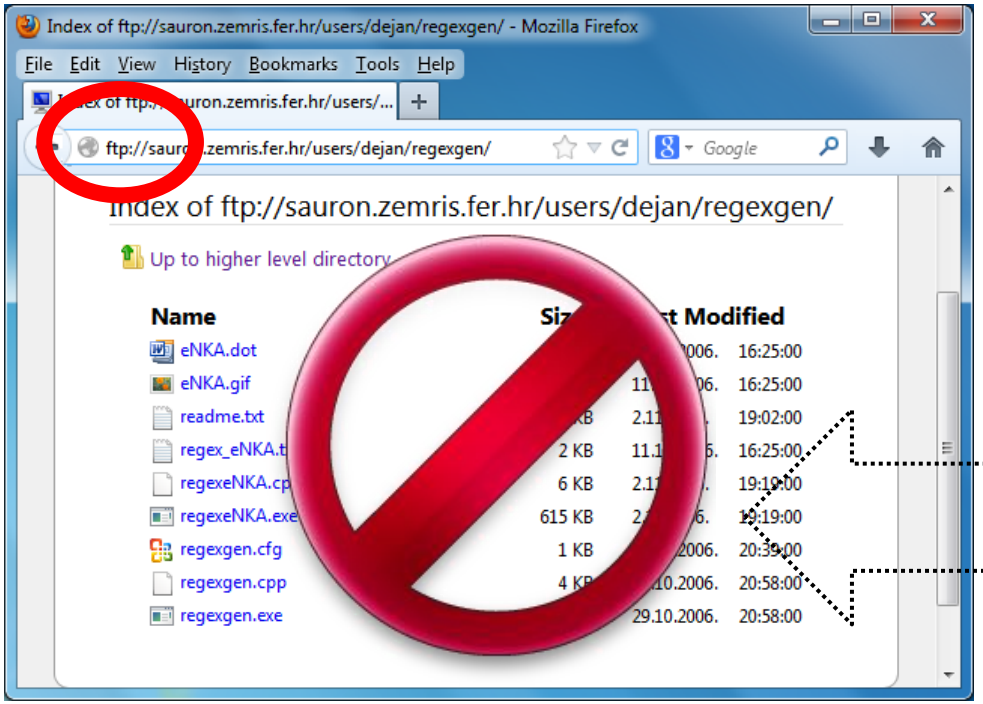




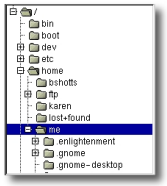
Internet vs. World Wide Web



Internet vs. World Wide Web



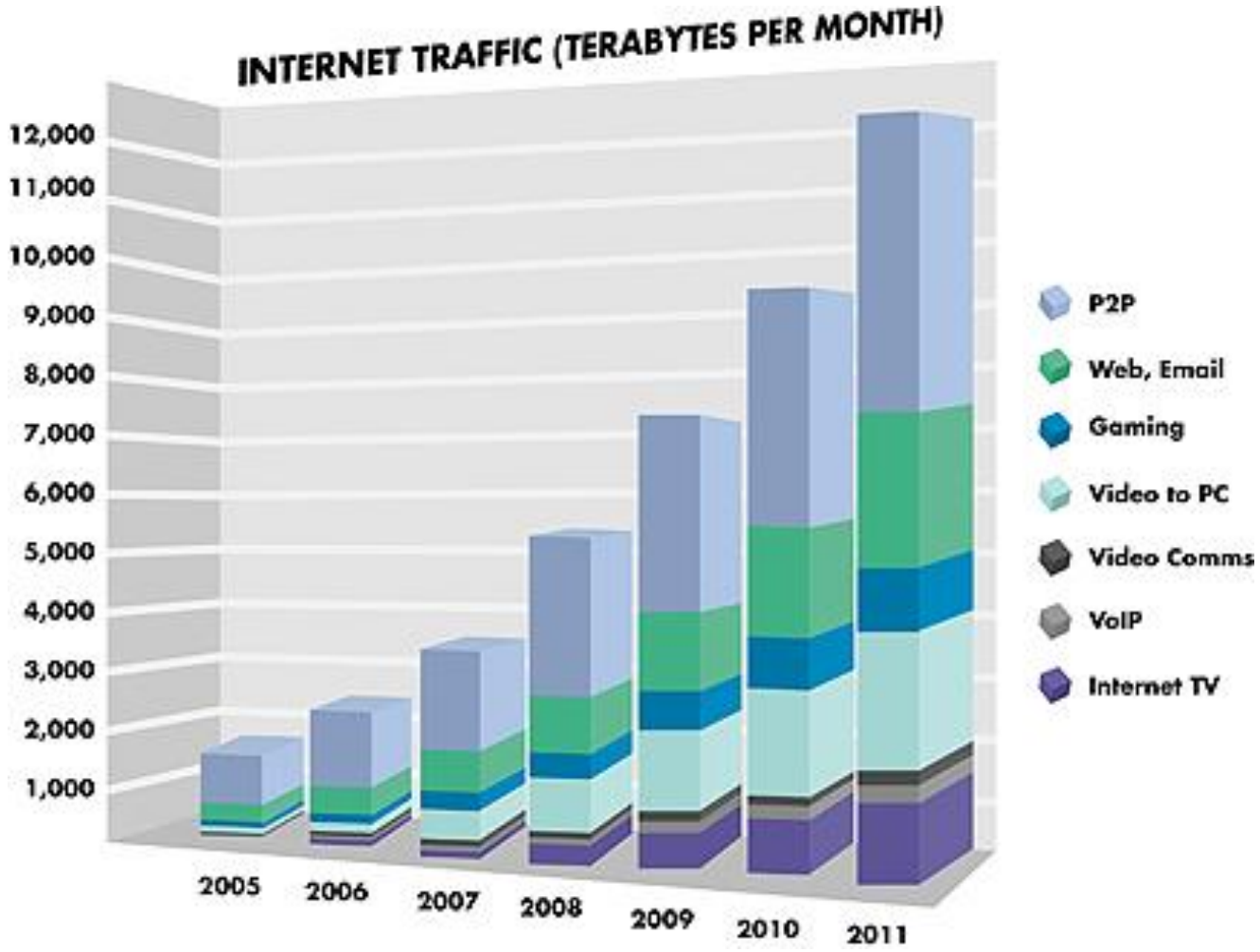
File system data
(directory structure,
file list,
file content)



FTP
(File Transfer Protocol)

File server

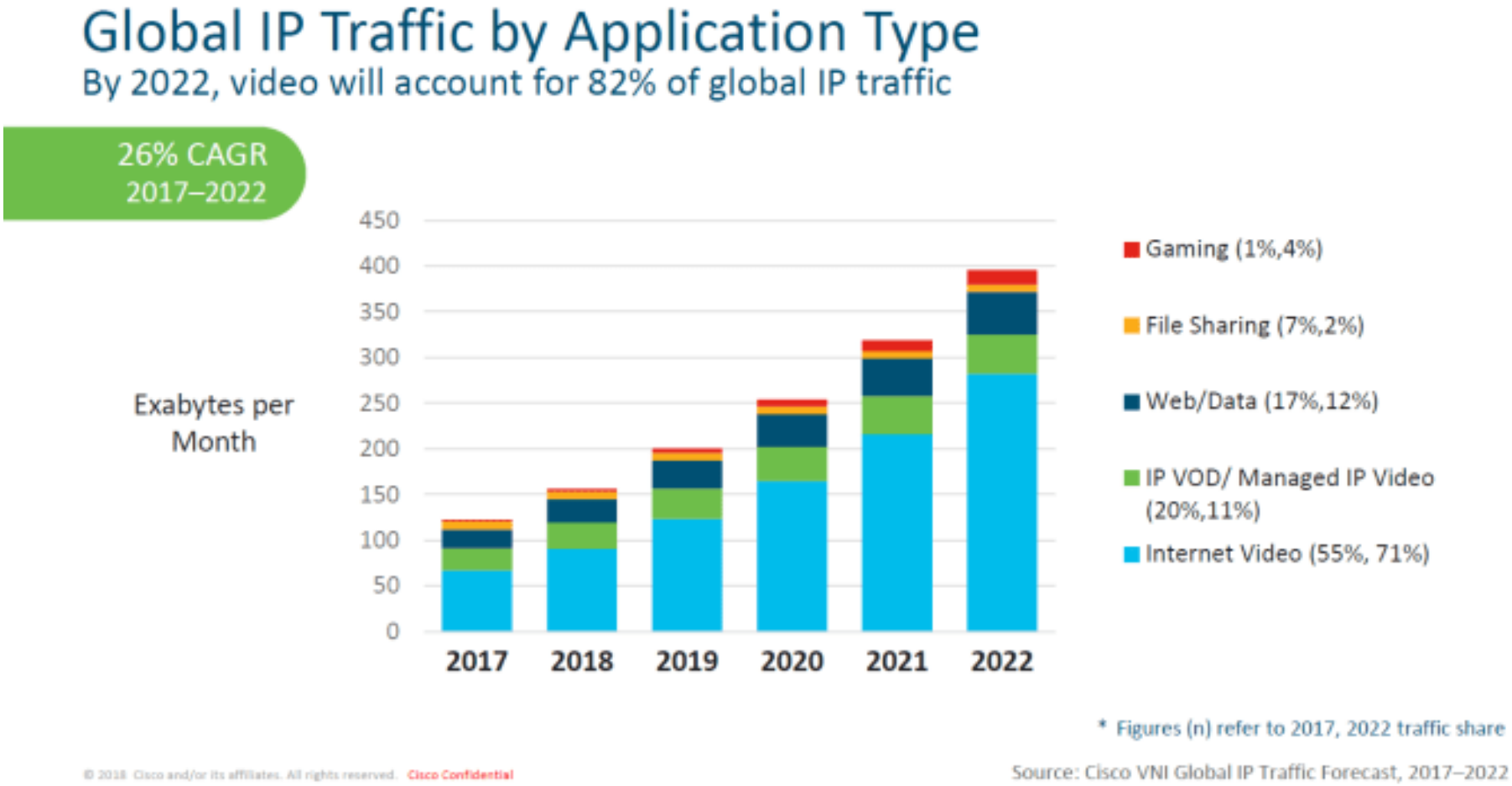
Why is Web Important to Us?



Source:

Cisco Systems, Inc: Global IP Traffic Forecast and Methodology, 2006-2011

Why is Web Important to Us?

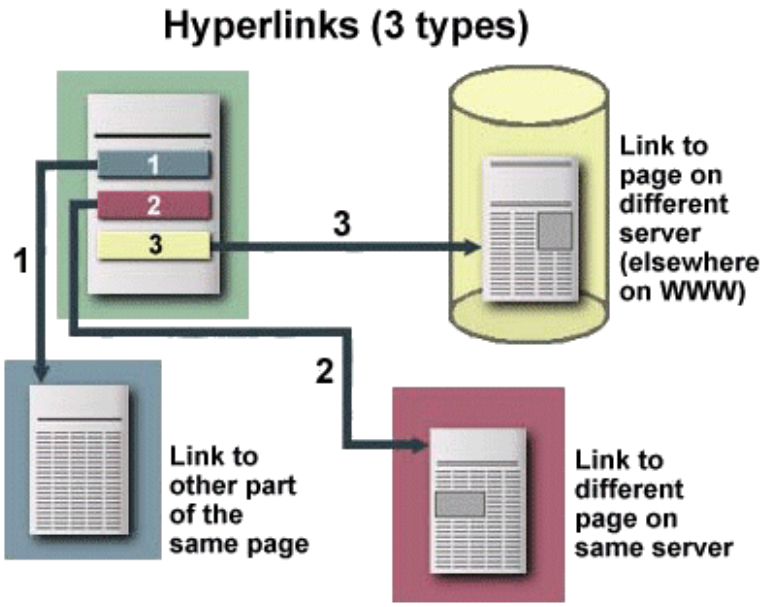


Source:

Cisco Systems, Inc: Cisco VNI Global IP Traffic Forecast 2017-2022

Why is Web Important to Us?

- Hypermedia
  - Interactivity
    - High degree of user's inclusion
    - Birectional flow of communication (data + commands)
      - Server-to-client
      - Client-to-server
  - Multimedia
    - Text
    - Graphics
    - Sound
    - Video
  - Connectedness
    - Links (hyperlinks)
    - Non-linear traversal of the World Wide Web space



A Word or Two About History

Sir Timothy John Berners-Lee
(*Tim Berners-Lee*)

– Inventor of the World Wide Web

http://www.cern.ch

http://www.w3.org

Internet before the World Wide Web

- Early research and development

1961	First packet-switching papers
1963	Ted Nelson coins the term HyperText
1966	Merit Network founded
1966	ARPANET planning starts
1969	ARPANET carries its first packets between UCLA and Stanford
1970	Mark I network at NPL (UK)
1970	Network Information Center (NIC)
1971	Merit Network's packet-switched network operational
1971	Tymnet packet-switched network
1972	Internet Assigned Numbers Authority (IANA) established
1973	CYCLADES network demonstrated
1974	Telenet packet-switched network
1976	X.25 protocol approved
1980	USENET news using UUCP
1980	Ethernet standard introduced
1980	Tim Berners-Lee built ENQUIRE, personal document collection (remote access+links)
1981	BITNET established

Internet before the World Wide Web

- Merging the networks and creating the Internet
- Announcement of the World Wide Web

1982	TCP/IP protocol suite formalized
1982	Simple Mail Transfer Protocol (SMTP)
1983	Domain Name System (DNS)
1985	First .COM domain name registered (symbolics.com, Cambridge, MA, USA)
1986	NSFNET with 56 kbit/s links
1986	Internet Engineering Task Force (IETF)
1987	UUNET founded
1988	NSFNET upgraded to 1.5 Mbit/s (T1)
1988	OSI Reference Model released
1988	Morris worm
1990	ARPANET decommissioned
1991	World Wide Web (WWW) *Tim Berners Lee built first web server, web browser, and HTML editor* *First application: CERN phonebook*

Web History Timeline

- Early stage web browsers and markup languages
- Server-side technologies
- Standardization bodies

1991	HTTP 0.9 specified by Tim Berners Lee
1992	ViolaWWW, first popular web browser
1993	HTML, IETF first draft (Tim Berners-Lee and Dan Connolly)
1993	Mosaic web browser (later Netscape Navigator) Cello web browser released by Microsoft
1994	Python 1.0 (Guido van Rossum)
1994	Netscape Navigator 1.0 web browser
1994	Full text web search engines
1994	World Wide Web consortium founded (W3C) *Director: Tim Berners Lee*
1995	Opera 1.0 web browser
1995	PHP (Personal Home Page Tools – PHP Tools)
1995	Internet Explorer 1.0
1995	Javascript
1996	CSS level 1

Web History Timeline

- Modern Web

1997	HTML 4.0
1998	XML 1.0
1998	Netscape went open source, Mozilla Foundation founded
2000	Dot-com bubble bursts
2000	REST defined by Roy T. Fielding, UCI
2001	Code Red I, Code Red II, and Nimda worms
2002	Web 2.0: blogs, wikis, RSS
2003	Safari 1.0 for Mac OS X
2004	Firefox 1.0
2005	Ajax
2005	Ruby on Rails 1.0
2006	jQuery JavaScript Framework 1.0
2007	iPhone announced
2008	Android 1.0 released
2008	Google Chrome
2011	Google+ social networking
2012	HTML 5.0

Popular Web Services

1990	IMDb Internet movie database
1995	Amazon.com online retailer
1995	eBay online auction and shopping
1995	Craigslist classified advertisements
1996	Hotmail free web-based e-mail
1997	Babel Fish automatic translation
1998	Google Search
1998	Yahoo! Clubs (now Yahoo! Groups)
1998	PayPal Internet payment system
1999	Napster peer-to-peer file sharing
2001	BitTorrent peer-to-peer file sharing
2001	Wikipedia, the free encyclopedia
2003	LinkedIn business networking
2003	Myspace social networking site
2003	Skype Internet voice calls
2003	iTunes Store
2003	4Chan Anonymous image-based bulletin board

Popular Web Services

2004	Facebook social networking site
2004	GMail
2004	Podcast media file series
2004	Flickr image hosting
2005	YouTube video sharing
2005	Google Earth virtual globe Google Maps Google Talk
2006	Twitter microblogging
2007	WikiLeaks anonymous news and information leaks
2007	Google Street View
2008	Amazon Elastic Compute Cloud (EC2)
2008	Dropbox cloud-based file hosting
2009	Bing search engine
2011	Google+ social networking

World Wide Web Today (as of July 2021)

4.7 billion of active users (2.4 billion in 2012)

250 million new users each year (700,000 each day)

1.89 billion web sites (697 million in 2012)

80 million websites added each year

1595 top-level domains (329 in 2012)

545 million registered domain names (246 mil. in 2012)

203 million .com domains (100 million in 2012)

18 million .net domains

14 million .org domains

121,000 .hr domains (77,000 in 2012)

7.1 billion mobile phone users (5 billion in 2012)

6.4 billion smartphone users (1.1 billion in 2012)

Source:

https://www.statista.com/study/12322/global-internet-usage-statista-dossier/

https://www.internetlivestats.com/total-number-of-websites/

https://domainnamestat.com/statistics/overview

https://www.domene.hr/portal/statistics

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World Wide Web Today (as of July 2021)

4.3 billion Google users

- 5.6 billion searches/day (63.000 searches/second)
- 135,000 employees (19,800 in 2009, 88,100 in 2017)
- $182 billion in revenue ($50 billion in 2012)

2.9 billion Facebook users (1 billion in 2012)

- 4.5 billion likes/day (3,125,000 likes/minute) (2.7 billion in 2012)
- 350 million new photos uploaded/day (300 million in 2012)
- 100,000 new friend requests/minute
- 9,200 employees
- $27.2 billion in revenue (cca. $10 per user)

2 billion WhatsApp users

- 100 billion messages/day

Source:

https://www.semrush.com/blog/google-search-statistics/
https://blog.wishpond.com/post/115675435109/40-up-to-date-facebook-facts-and-stats
https://www.statista.com/study/11677/google-statista-dossier/
https://www.oberlo.com/blog/whatsapp-statistics